Juno Radio Science Observations and Gravity Science Calibrations of Io Plasma Torus: IPT Impacts to Europa Gravity Science

Yu-Ming (Oscar) Yang[1], Dustin Buccino[1], Marzia Parisi[1], William M Folkner[1], Phillip H Phipps[2], Daniel S Kahan [1], Paul Withers [2], Kamal Oudrhiri [1]

(1) Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA
(2) Boston University, Boston, MA, USA

Jet Propulsion Laboratory
California Institute of Technology

Outline

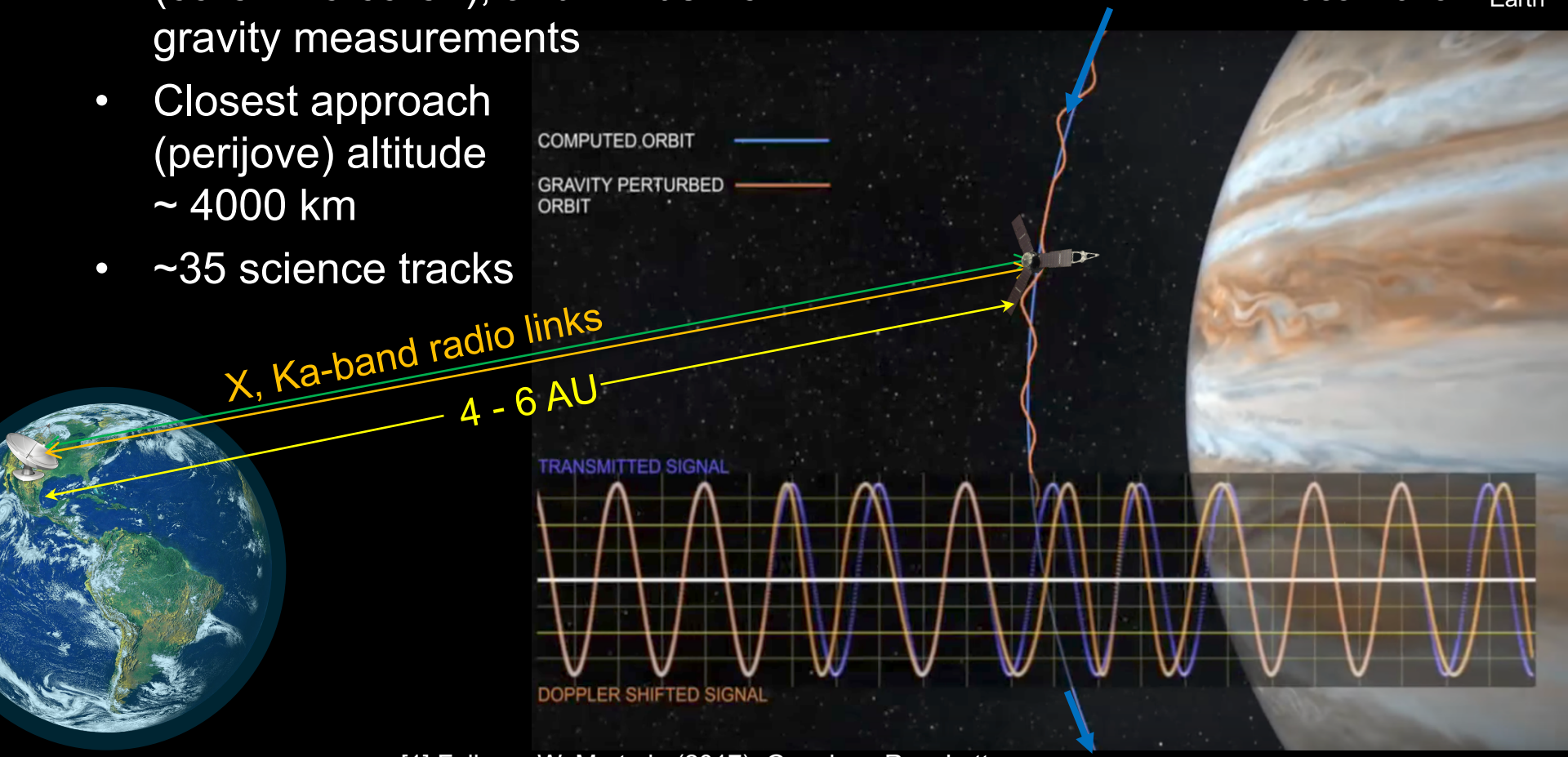
- Introduction – Juno Gravity/Radio Science
- Scientific Background - Io Plasma Torus
- Method and Measurements
- Observations and Model Simulations
- Impact to Europa Clipper Radio/Gravity Science Measurements
- Summary and Future Work

Introduction – Juno Gravity/Radio Science

Gravity Science:

- Map Jupiter's gravity field [1]
- Determine mass, interior structures (core? No core?), and winds from gravity measurements
- Closest approach (perijove) altitude ~ 4000 km
- ~35 science tracks

Jupiter
Radius ~ 11 R_{Earth}
Mass ~ 318 M_{Earth}

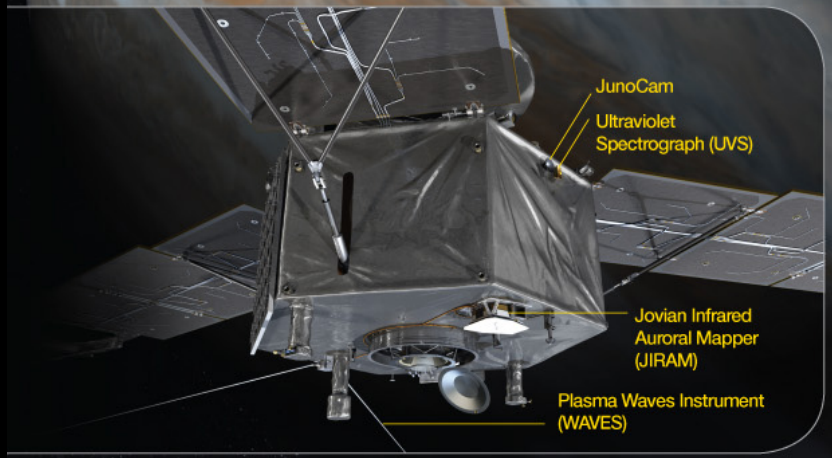


[1] Folkner, W. M et al., (2017), Geophys. Res. Lett.

Introduction – Juno Instruments

Juno Spacecraft

National Aeronautics and Space Administration



SPACECRAFT DIMENSIONS

Diameter: 66 feet (20 meters)
Height: 15 feet (4.5 meters)

For more information:
missionjuno.swri.edu &
www.nasa.gov/juno

Juno's Instruments

Gravity Science and Magnetometers
Study Jupiter's deep structure by mapping the planet's gravity field and magnetic field

Microwave Radiometer
Probe Jupiter's deep atmosphere and measure how much water (and hence oxygen) is there

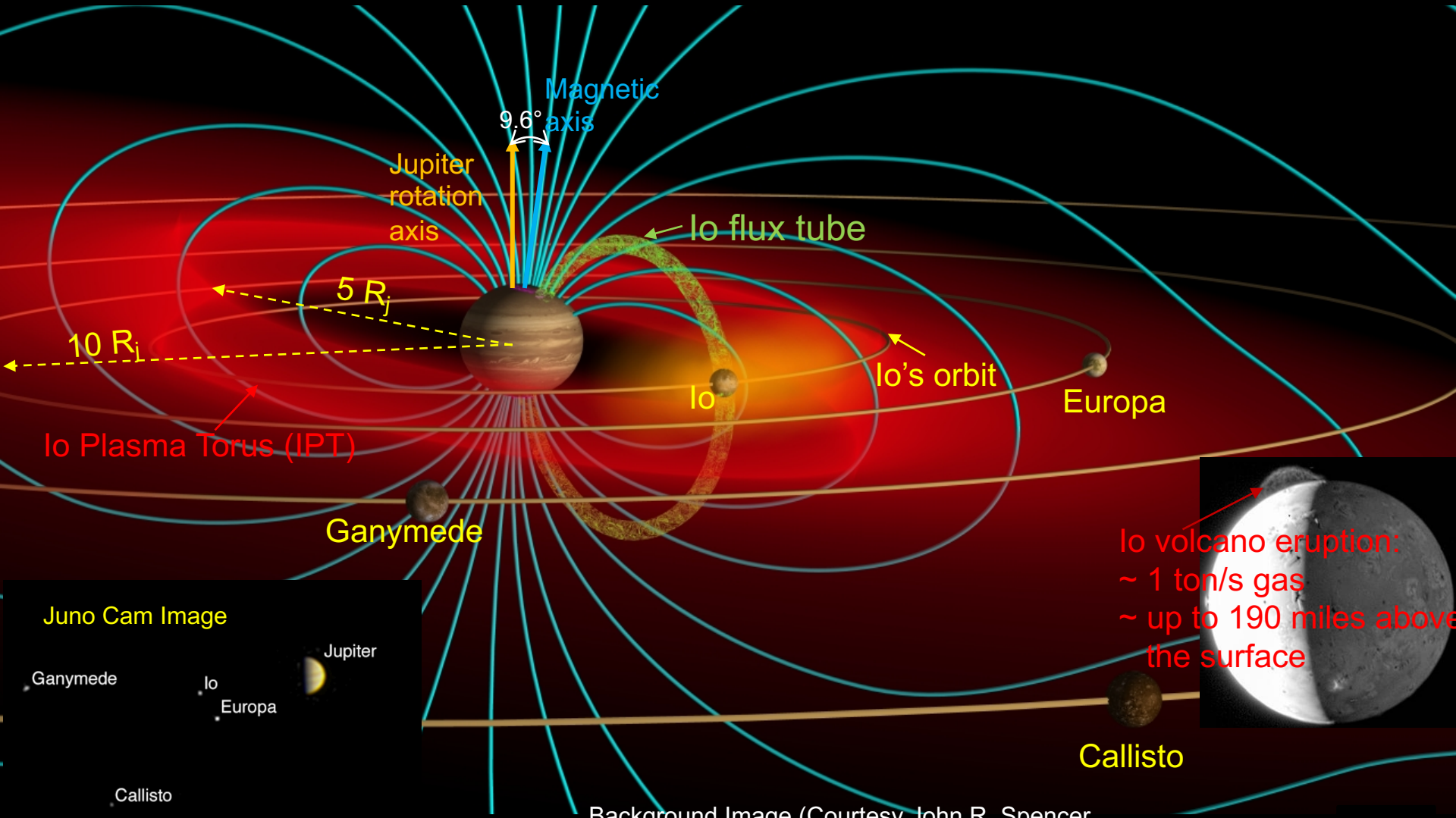
JEDI, JADE and Waves
Sample electric fields, plasma waves and particles around Jupiter to determine how the magnetic field is connected to the atmosphere, and especially the auroras (northern and southern lights)

UVS and JIRAM
Using ultraviolet and infrared cameras, take images of the atmosphere and auroras, including chemical fingerprints of the gases present

JunoCam
Take spectacular close-up, color images

National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California
www.nasa.gov

Scientific Background – Io Plasma Torus (IPT)

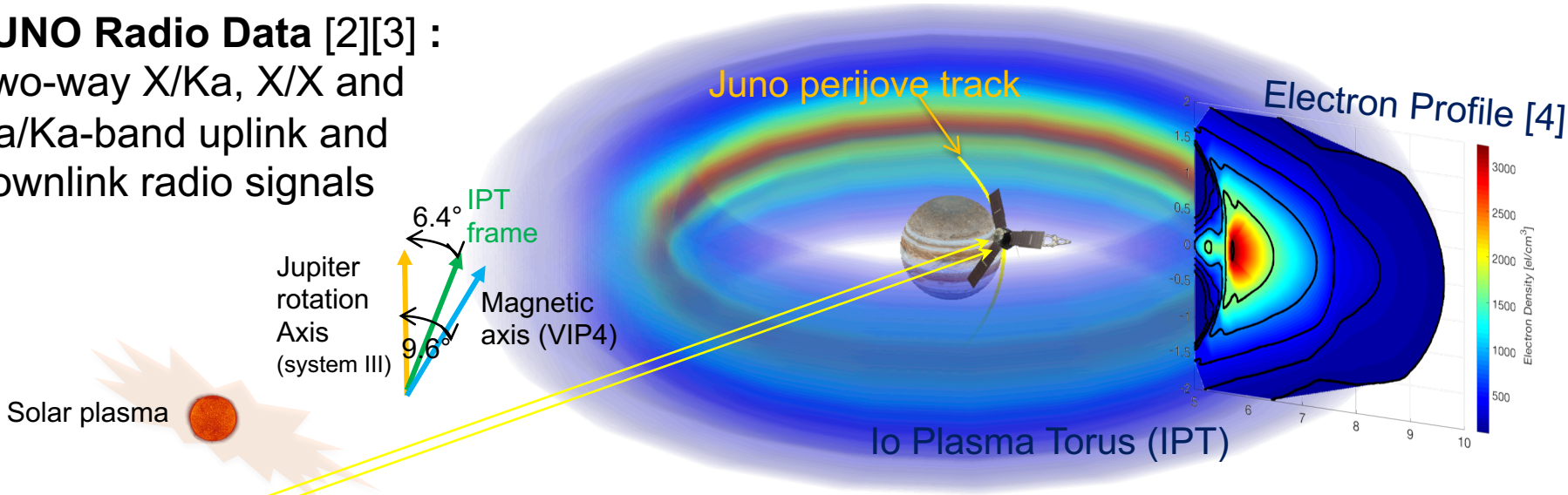


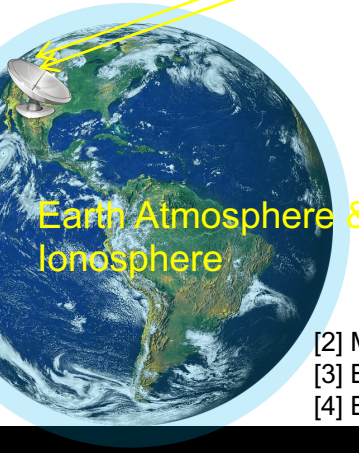
Background Image (Courtesy John R. Spencer, Southwest Research Institute)

Method and Measurements

To Study IPT Impacts to Juno Gravity Science Measurements

JUNO Radio Data [2][3] **:**
Two-way X/Ka, X/X and Ka/Ka-band uplink and downlink radio signals





Doppler shift of carrier frequency:

Earth Atmosphere

$$\Delta f\,(Hz) = \Delta f_{obital\ motion} + \Delta f_{non-dispersive\ media} + \Delta f_{dispersive\ media}$$

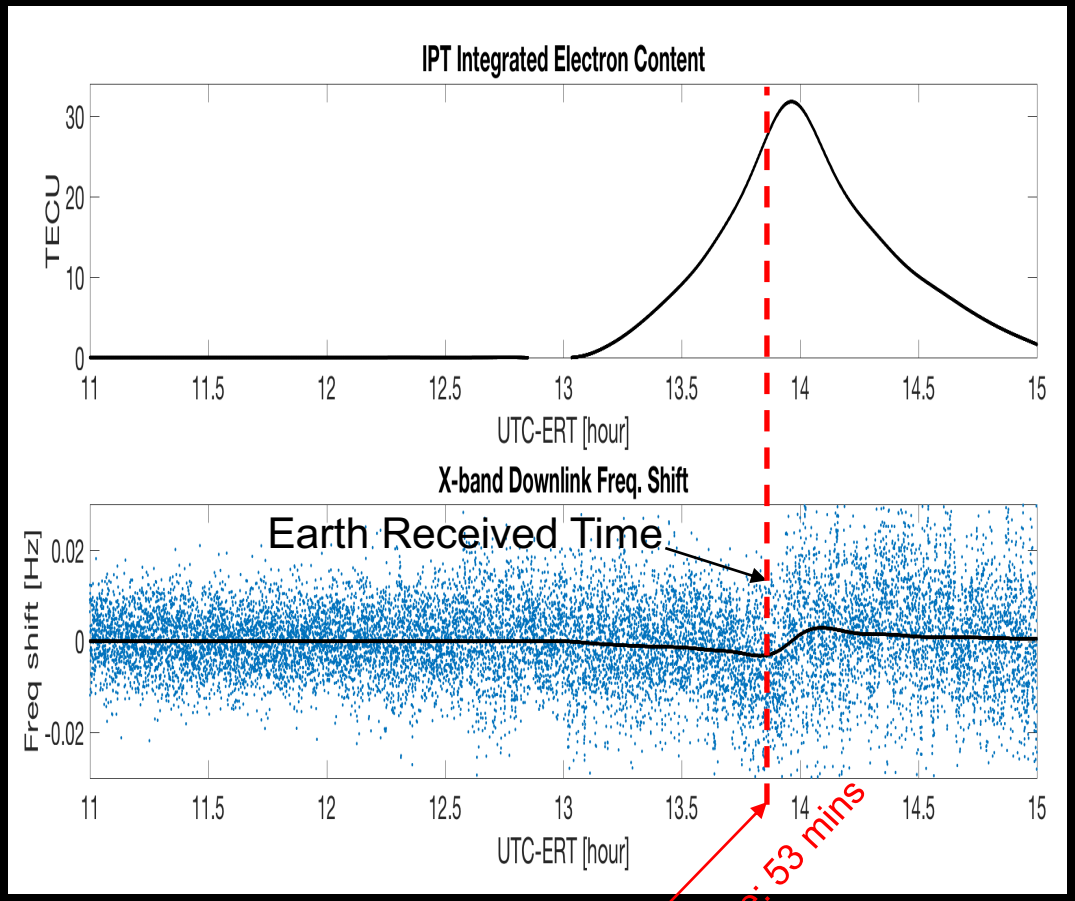
Gravity Science Measurements (Gravitational fields)

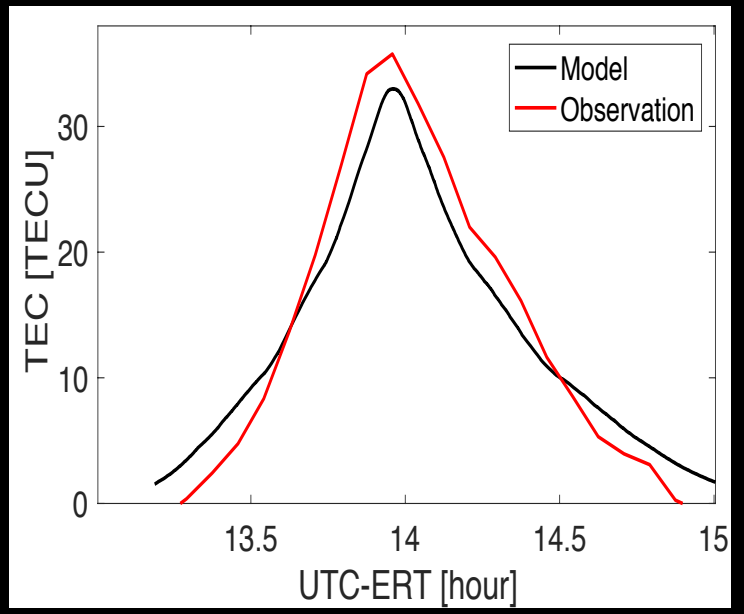
Plasma Electrons (Earth, Solar, IPT)

[2] Mukai et al.(2012), Juno Telecommunications, JPL
[3] Buccino et al., Initial Operations Experience and Results from the Juno Gravity Experiment, 2018 IEEE Aerospace Conference,
[4] Bagenal, F. (1994), J. Geophys. Res.

The First Science Orbit/Track Observations

Perijove 01(PJ-01) Doppler Measurements





The discrepancy between observations and model simulations might be from solar plasma or earth ionosphere.

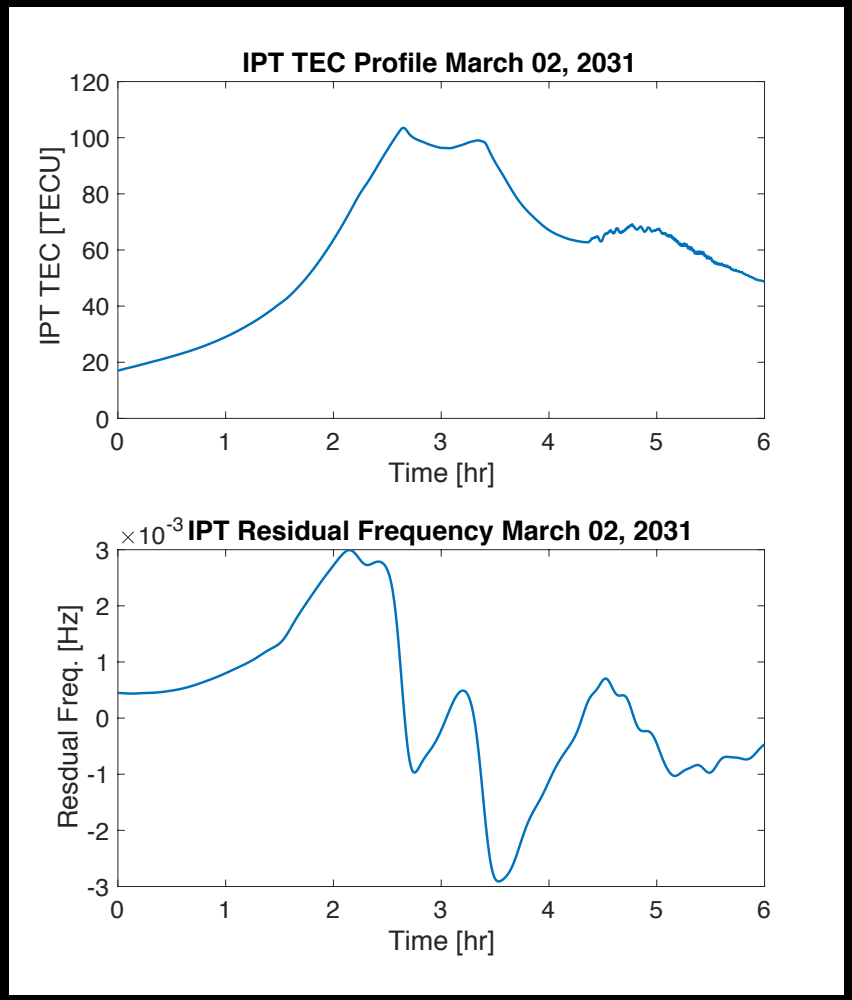
Spacecraft Time

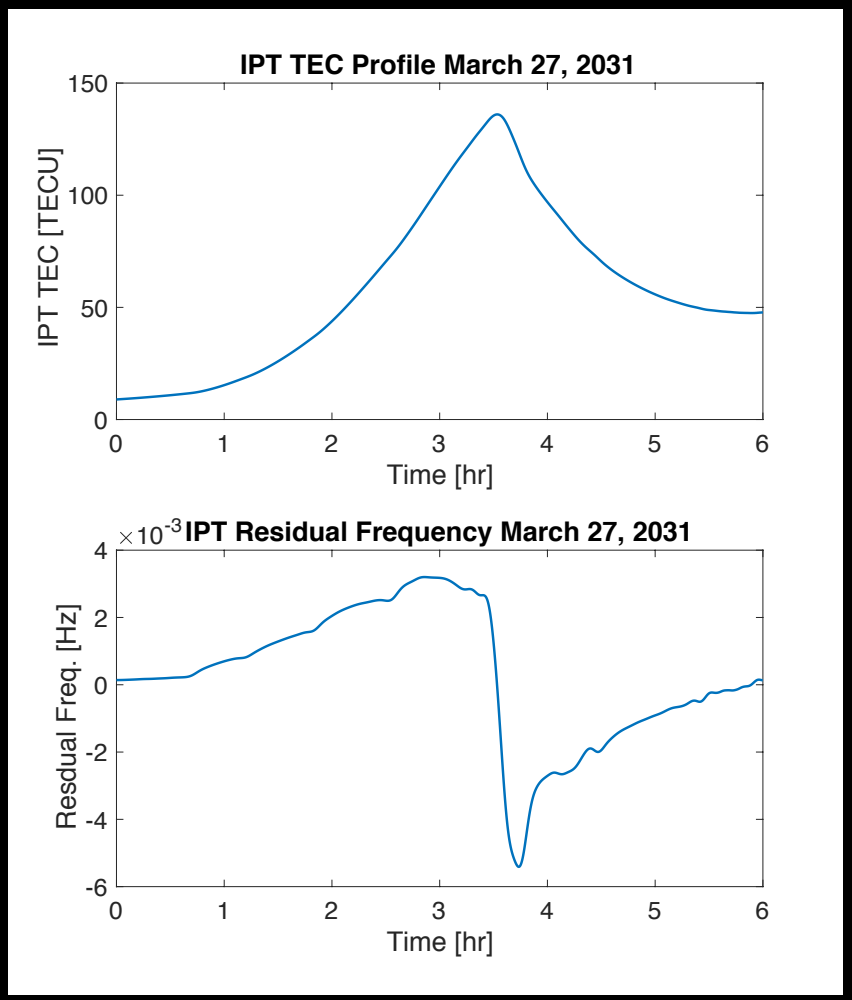
closest approach
8/27 T12:51

Light Time: 53 mins

IPT Impact to the Europa Clipper Radio Science Data

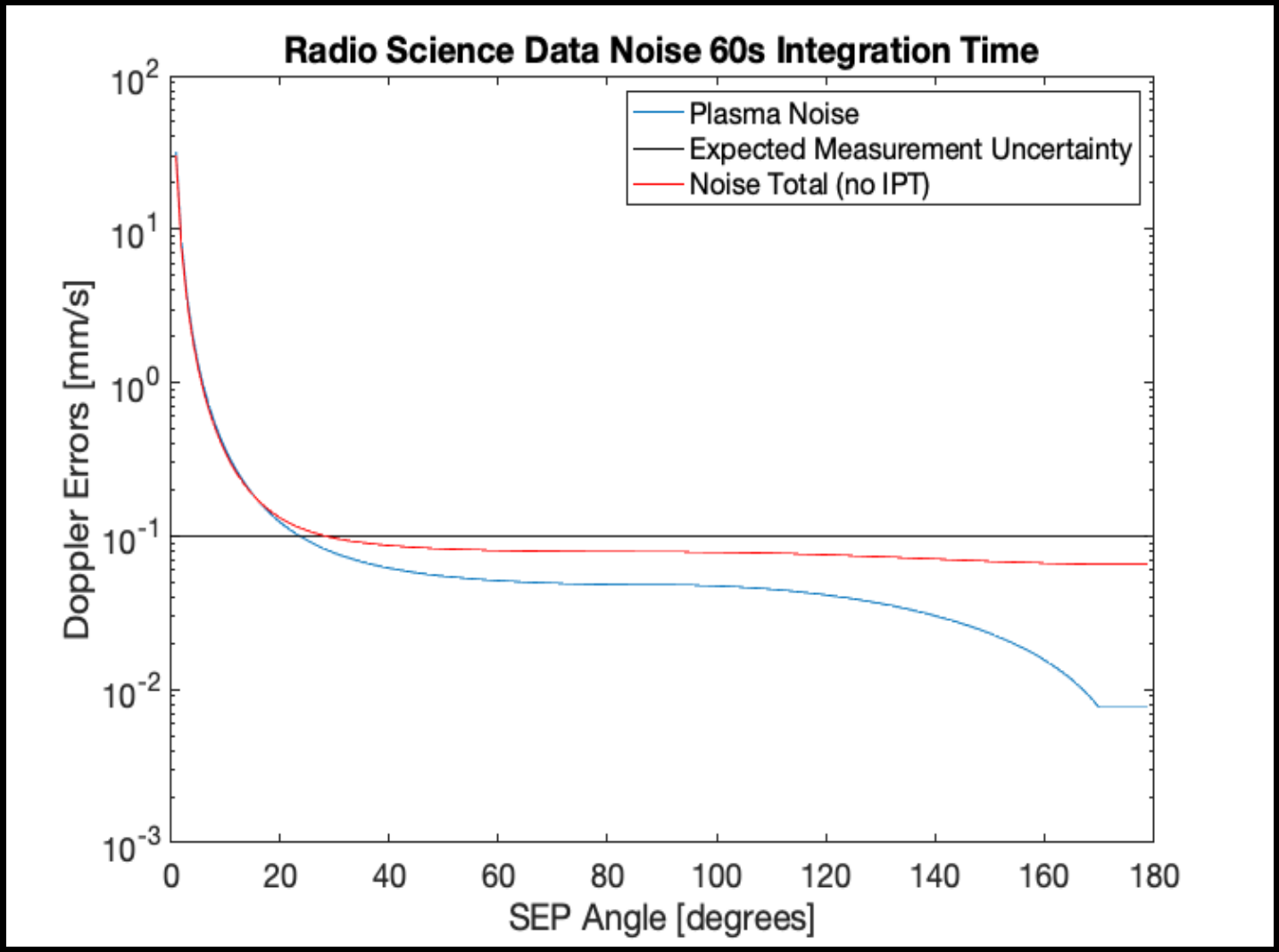
Simulations and Analysis (1)





IPT Impact to the Europa Clipper Radio Science Data

Simulations and Analysis (2)



Summary and Future Work

- Juno gravity/radio science measurements are sensitive to plasma electrons inside Io Plasma Torus
- Significant IPT plasma electron variations of up to ~30 TEC units were derived using Juno Radio/Gravity science measurements
- Simulations indicated the IPT will impact the Europa clipper radio science measurements
- Model Calibrations of Io Plasma Torus impacts will improve the X-band radio science measurements of the Europa mission

Acknowledgments

This work was supported as a part of the work on Gravity and Radio Science experiment on NASA's Juno Mission.

Contact Information:

Yu-Ming Yang, Planetary Radar & Radio Sciences Group, JPL
Email: Oscar.Yang@jpl.nasa.gov ;
Phone: 818-354-5747

Kamal Oudrhiri (supervisor), Planetary Radar & Radio Sciences Group, JPL
Email: kamal.oudrhiri@jpl.nasa.gov